The STOVL Joint Strike Fighter – From a Harrier Skeptic

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STOVL JSF- From a Harrier Skeptic

History

In 1957, The 21st Commandant of the United States Marine Corps, General Randolph McCall Pate, committed the Marine Corps to a vision of becoming an "All STOVL" (Short Take Off Vertical Landing) force. It is now 2002 and the Marine Corps has yet to achieve this vision. However, with the successful flight tests of the X-35B (STOVL variant JSF) and the Joint Strike Fighter (JSF) contract being awarded to Lockheed Martin on 26 October 2001, the vision of General Pate is nearing reality as the JSF is slated to hit the operational Marine Corps as early as 2010.

> Over the next decade, the vision will become reality as the Corps fields the STOVL Joint Strike Fighter and the MV-22. As have all Commandants before me, I add my strongest endorsement to this transformation…it will ensure the Corps continues to stand ready in defense of our Nation.[2]

The Question

There is now one key question to ask: "Is the STOVL JSF the correct aircraft to bring Marine Corps' tactical aviation from a vision of the 21st Commandant to the 21st Century?" I believe the answer is, "Yes." The STOVL JSF is the aircraft to do the job as it maximizes flexibility and forward basing, decreases reaction time, increases payload brought to the battlefield, and enhances the "A" in Marine Air Ground Task Force (MAGTF). However, in order to maximize the STOVL JSF's potential it is

[2] James L. Jones, Commandant, USMC, "The Future of Expeditionary Air Power…," JSF promotion book, 2001, 2.

necessary that the Marine Corps has the complete cooperation of the United States Navy.

Harrier Argument

Skeptics of the AV-8 "Harrier" argue that STOVL is forever a flawed concept, and proof of this is readily available when you focus your attention on the Harrier. (This aircraft was bought from the British after Major General Keith B. McCutcheon, USMC Deputy Chief of Staff for aviation, saw a Harrier promotional film in 1968.[3]) The skeptics say the Harrier is a drain on the budget of the Marine Corps as it has had repeated catastrophic engine failures and lacks the combat payload and radius needed to make it a valued Marine Corps attack aircraft. I know this; I was one of these skeptics. However, I now understand that these are limitations of the Harrier, a third generation STOVL design, and *not* of the STOVL concept.

The Harrier has two main flaws in its design: the large "super critical" wing, and the jet engine intake.[4]

The super critical wing was a design change from the AV-8A to the AV-8B and was done in order to generate more lift at low airspeeds. Thus, lowering its stall airspeed and increasing the amount of payload it can take off with. However, due to the size and aerodynamic shape of the wing it does not perform well

[3] Ben D. Hancock, Major, USMC, "The STOVL Joint Strike Fighter in Support of the 21st Century Marine Corps", CSC 1997, 19.
[4] Geoff Eich, Captain, USMC, AV-8B Harrier pilot, interview by author, 31 January 2002.

at high altitudes (above 20,000 feet).[5] Initially, this was not a factor as the aircraft was designed in the Viet Nam era for low altitude ingress and egress. However, with the current Surface to Air Missile (SAM) threat on the battlefield, the Harrier is now forced to fly at high altitudes, a region outside the Harrier's primary design.

The jet engine intake on the Harrier, due to the need for air in the jet engine, while at a hover or during vertical landing, was placed very close to the engine inlet.[6] This design feature greatly reduces the engine performance, limiting the Harrier's top speed, combat radius, and payload, while increasing both drag and Radar Cross Section (RCS).

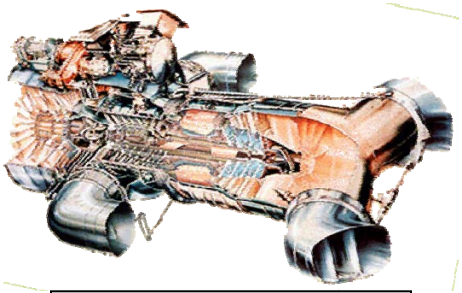

Fig 1: Diagram of AV-8B engine.

Fig 2: Looking down the intake of the AV-8B you can see the compressor fan blades immediately behind the Harrier's engine inlet.

Technology has facilitated the elimination of both design flaws in the Harrier. On the Marine Corps' STOVL JSF variant, the aircraft has a relatively thin aerodynamic wing. The same wing is used by the Conventional Take Off and Landing (CTOL)

[5] Eich interview.
[6] Eich interview.

variant of the JSF. In relation to the second design flaw, the engine placement of the STOVL JSF is the same as on the other variants (further back from the engine inlet). This placement is possible because the jet engine and lift fan on the STOVL JSF, while in hover, get their air from inlets on the top of the fuselage.

 [7]
 [8]
 [9]

Figs 3-5: Notice on the top of the fuselage, while performing a vertical landing or at slow airspeeds, the lift fan inlet air duct doors are open.

Two other points that bring strong criticism to the Harrier: the repeated catastrophic engine failures and the lack of a substantial combat payload and radius. The first refers to the number three engine bearing of the Harrier. This is a recent problem and pertains only to the Harrier engine. There are no parallels in the design of the Harrier engine and the STOVL JSF engine. In fact, the STOVL JSF engine, the Pratt and Whitney JSF119-611, is a derivative of the F119 fitted on the F-22 Raptor, which is the same in all variants of the JSF.[10] Second, when addressing the issue of combat payload and radius,

[7] Image from www.lmtas.com/news/programnews/combat_air/x35/x35_01/x35pr010716.html
[8] Image from www.af.mil/news/Mar2001/n20010326_0417.shtml
[9] Image from www.airforce-technology.com/projects/jsf/index.html#jsf9
[10] www.naval-technology.com/projects/jsf/, "Joint Strike Fighter", January 2001.

one must understand that this is also a function of the design. The Harrier was acquired and designed to carry 3,000 pounds of ordnance 35 to 50 miles with a loiter time of 5 minutes over the target.[11] It performed that mission well! Therefore, it is incorrect to assume that the small payload and radius is a factor of the STOVL concept itself. Rather, it is a function of the Harrier design.

STOVL JSF

The four largest benefits of the STOVL JSF are: flexibility and forward basing, reaction time, payload, and, most importantly, it enhances the "A" in MAGTF.

Flexibility/Forward Basing

The most unique feature of the STOVL JSF is indeed the "Short Take Off" and "Vertical Landing" capability. This capability allows the STOVL JSF to take off with a full combat load using only 2000 feet of runway while most other modern day fighter/attack aircraft need 8000 feet to perform this task. This ability to take off in such a short distance means there are approximately six times the amount of airfields around the globe usable by the STOVL JSF, but not by most other fighter/attack aircraft. Not to mention, if (in a conflict such as the Gulf War, or Afghanistan and the ongoing War on

[11] Bruce Myles, Jump Jet The Revolutionary V/STOL Fighter, (London: Brassey's Defense Publisher, 1986), 181.

Terrorism) we bomb a larger airfield and later occupy the airfield, it is probable that there will still be 2000 feet of runway that remains usable by the STOVL JSF. With little or no repair to the taxiways, the airfield will be operational for the Marine Corps' STOVL JSF. To the Marine Corps, this translates into *flexibility* and an unlimited potential for *forward basing*.

Reaction Time

By default, an aircraft that is based within 100 miles of the battlefield and the Forward Line Of Troops (FLOT) is going to have a much quicker reaction time than an aircraft based several hundred miles back in another allied country or on the aircraft carrier.

Even if the base in the allied country is geographically close to the battlefield, the potential remains that we may not be able to fly sorties out of the base for political reasons. For example, one only needs to listen to "CNN" or "Fox News Channel" to realize that this scenario may play out in Saudi Arabia if the United States includes Iraq in the War On Terrorism.

What about the aircraft carrier? Though it may be geographically close, the United States may not have permission to fly over any country that lies between the carrier and the battlefield. For example, Afghanistan is geographically close to the Arabian Sea; however, if Pakistan joined Iran in denying

the United States the use of their air space, the strategic location of the carrier would be of no benefit.

One of the, if not the best, benefits of a reduction in *reaction time* is the increased likelihood of destroying "targets of opportunity". With a *forward base* that may be only a ten to fifteen minute flight from the FLOT, the STOVL JSF may be able to destroy a "target of opportunity" before the target has the time to hide or drive out of range for the aircraft. The STOVL JSF's reduction in reaction time would have proven to be very beneficial in targeting mobile scud launchers during the Gulf War.[12] In addition, the STOVL JSF will be able to be on station and influence the battle long before another aircraft based hundreds of miles back in another country [disavowing tanker times and slot times for aircraft to be in the Area of Responsibility (AOR)].

Payload

The Marine Corps' payload requirement for the STOVL JSF is 11,500 pounds. To date, the payload performance of the X-35B has been 13,500 pounds.[13] This is more than four times the original design of the Harrier, and more than twice its current capability. How does this compare with the other variants of the JSF? The STOVL JSF itself does not carry more ordnance than

[12] Dr. Eliot A. Cohen, Gulf War Air Power Survey Vol. I, (US Government Printing Office, Washington DC 1992), 242-253.
[13] X-35B Concept Demonstration Statistics, Lockheed Martin

the other JSF variants. Instead, the payload benefit the STOVL JSF brings is two-fold. First, it does have more payload than the Harrier and is on par with that of the F/A-18 and the other JSF variants. Second, the previously mentioned benefits of *forward basing* and *reaction time* have a synergistic affect on *payload*. That is, the STOVL JSF can make multiple trips from the *forward base* to the battlefield while the other variants of the JSF may still be in transit and/or affected by deck cycles. This capability is undoubtedly a combat multiplier that gives the Marine Corps the option of striking more targets with more ordnance in a shorter period of time.

USMC Key Performance Parameters and X-35B Performance[14]

KPP	USMC Requirement	X-35B (STOVL JSF)
Stealth	Very Low Observable (VLO)	VLO
Combat Radius (note 1)	450nm	490nm
Internal Payload Capacity	2x 1000# JDAM + 2x AMRAAM	2x 2000# JDAM + 2x AMRAAM[15]
Total Weapons Payload	11,500#	13,500#
T/O Performance (note 2)	3,000# Ordnance + full fuel	5,500# Ordnance + full fuel
Recovery Performance (note 3)	3,000# Ordnance + STOVL Bringback fuel	4,500# Ordnance + STOVL Bringback fuel

Notes: (1) High-Medium-High altitude profile
(2) Unassisted T/O with a deck roll of 550' and 15 knots Wind Over Deck (WOD)
(3) STOVL Bring back fuel is sufficient for (2) IFR passes plus STOVL reserve

"A" in MAGTF

As all Marines know, the "A" in MAGTF stands for *Air*. This is an extremely unique ability of the Marine Corps that allows

[14] X-35B Concept Demonstration Statistics, Lockheed Martin
[15] The 2x 2000# Internal Payload Capacity is a capability of the X-35B given some modifications to the bomb bay and the replacement of the bomb bay doors with the doors used on the CTOL variant of the JSF. Currently the X-35B has proven its Internal Payload Capacity at 2x 1000#.

its MAGTF [whether it is a MEF (Marine Expeditionary Force), MEB (Marine Expeditionary Brigade), MEU (Marine Expeditionary Unit), or Special Purpose MAGTF] to fight as a complete unit with all the benefits of air power, while having the multiplying force of the Marine infantry on the ground. It is a force, which uses the sound doctrine of "Combined Arms" while capitalizing on the concept of Expeditionary Maneuver Warfare (EMW). Unfortunately, the Harriers that usually fill a portion of the *air* in MAGTF have been unable to support the ground Marines in recent years due to engine troubles. This gap in air support was temporarily filled by Marine F/A-18 "Hornets". This is evident by VMFA(AW)-533 (Marine All Weather Fighter Attack Squadron-533) "Hawks" filling a Harrier gap in the beginning of 2001 with the 31st MEU(SOC). However, this problem will be permanently solved when the STOVL JSF joins the FMF (Fleet Marine Force) in 2010. The STOVL JSF addition to the Marine Corps will greatly enhance the "A" in MAGTF and brighten the future of an already time-tested Marine Air Ground team.

OMFTS

As Operational Maneuver From The Sea (OMFTS) implies, it is necessary for the Marine Corps to keep its close ties to the Navy. The reverse statement, that the Navy must keep its close ties with the Marine Corps, is also true. In order for the Marine Corps and Navy to be successful at OMFTS, the two

services must continue to work as a team. The Marine Corps would have absolutely no influence or power ashore if the Navy did not get them there and the Navy would be less of a threat if it did not have the Marine Corps to bring its influence into the depths of a hostile country. Therefore, if the Marine Corps is to invest fully in the STOVL JSF, the Navy must entirely support the Marine Corps with its amphibious fleets and Carrier Battle Groups (CVBGs).

Carrier STOVL Operations / Ramps

For the Marine Corps and Navy to reap the full benefits of the STOVL JSF, it must be deployed on carriers. In addition, the Navy should modify both the Tarawa and Wasp class (LHA/LHD) ships to include a ramp (ski jump). These two issues are not received well by most naval officials. Their arguments are: STOVL aircraft on the carrier will hinder the deck cycle, and modifying the LHAs and LHDs with a ramp is too costly (in addition to losing one helicopter deck spot). However, it has been proven in many studies conducted by the American Institute of Aeronautics and Astronautics (AIAA) that both would greatly assist the Navy in sortie rate and deck cycle impacts.

Carrier

On a carrier the operations of STOVL recovery and respot are greatly simplified. In addition, vertical landing pads on the port side of the carrier take up less area than the landing

area required for normal carrier aircraft. This facilitates the simultaneous operations of launch, recovery, and respot. Therefore the flight deck is never fouled for any single operation, thus reducing the impact on sortie generation. For STOVL, the limiting factor of sortie generation then becomes aircraft servicing rate.[16]

> Today's CTOL carrier airwing has reached a near optimum level of mission performance. That is, no increase in airwing size or availability will result in increased maximum sorties attainable…VSTOL, on the other hand, has been shown to be limited by the servicing cycle only. Here significant increases in sortie generation capability and decreases in numbers of aircraft required to support that capability are attainable simply by increasing the number of servicing crews.[17]

It is evident from this excerpt and other studies by AAIA that the STOVL JSF on the carrier will not hinder operations. In fact, it will contribute to a better deck cycle and more sorties.

LHA/LHD and Ramps

The next step the Navy should take in support of the Marine Corps and the STOVL JSF is to modify its LHAs and LHDs with a bow ramp. By doing so, The Navy will increase the combat payload a STOVL JSF can bring to the battlefield, while improving deck cycle. With a ramp on the bow of the ship, the

[16] "CTOL/VSTOL Comparison-A View from the Deck", AIAA Aircraft Systems Meeting, Aug. 4-6, 1980, 10.
[17] "CTOL/VSTOL Comparison-A View from the Deck", AIAA Aircraft Systems Meeting, Aug. 4-6, 1980, 10.

STOVL JSF can take off in only 400 feet, freeing the aft end of the ship for concurrent helicopter and MV-22 operations.

> The Harrier's takeoff performance was dramatically enhanced; the heaviest Harrier-31,000 pounds-ever from the deck of any ship was launched from the [Spanish carrier, Principe de Asturias] with a deck run of only 400 feet. An aircraft whose weight precluded its launch from any LHA or LHD, even using the entire deck, used the ski jump to take off in approximately one-half that distance.[18]

Conclusion

The STOVL JSF is the correct aircraft to make reality our 21st Commandant's vision and bring the Marine Corps into the 21st century. With the benefit of technology solving some of the problems that have plagued the AV-8 "Harrier" in the past, the STOVL JSF will bring the Marine Corps the benefits of *flexibility and forward basing*, decreased *reaction time*, increased *payload* to the battlefield, while increasing the effectiveness of the *"A"* in MAGTF.

However, in order for the Marine Corps to reap all the benefits of the STOVL JSF the Navy must support the Marine Corps' STOVL decision by allowing these aircraft on their carriers and modifying both LHA and LHD class ships with a bow ramp. If the Navy fails in their support for the Marine Corps' variant of the JSF, it will still be a success, but one that will never reach its full potential.

[18] Major Art Nalls, USMC, "Why Don't We Have Ski Jumps," U.S. Naval Institute *Proceedings*, Nov 1990, 81.

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